N 62 72590

NASA TT F-66

NASA TT F-66

TECHNICAL TRANSLATION

F-66

EXPERIMENTAL DETERMINATION OF POTASSIUM VAPOR PRESSURE IN THE 550° TO 1,280° C TEMPERATURE RANGE

By N. S. Grachev and P. L. Kirilov

Translated from Inzhenerno-Fizicheskiy Zhurnal, T. III, No. 6, June 1960

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON July 1961

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TECHNICAL TRANSLATION F-66

EXPERIMENTAL DETERMINATION OF POTASSIUM VAPOR PRESSURE

IN THE 550° TO 1,280° C TEMPERATURE RANGE*

By N. S. Grachev and P. L. Kirilov

F
6
6

When using metals as heat transfer fluids at high temperatures, it is necessary to know their vapor pressure. Potassium, either pure or in alloy form with sodium, is one of those potential heat transfer fluids. The results of various investigations at temperatures below 827° C were compiled by Ditchburn and Gilmour in reference 1, in which, after generalizing the results, the authors obtained the equation for the calculation of potassium vapor pressure:

$$\log P_s = -\frac{4,552}{T} - 0.5 \log T - 8.793 \qquad (1)$$

where P_s is the pressure in mm Hg, and T is the temperature in degrees Kelvin. The authors estimate the accuracy of formula (1) to be 5 percent.

The only available work on the investigation of potassium vapor pressure above atmosphere pressure is by Makansi, Muendel, and Selke (ref. 2). The upper temperature limit in these experiments was 1,007° C. The dependence of vapor pressure on temperature is described by the equation

$$\log P_s = -\frac{4,207}{T} + 4.096$$

where P_s is the pressure in atmospheres, and T is the temperature in degrees Kelvin.

In similar work on measurement of sodium vapor pressure (ref. 3), we obtained somewhat different results. The objective of the present work is to verify the data presented in reference 2 and also to broaden the investigated temperature interval.

---

*Translated from Inzhenerno-Fizicheskiy Zhurnal, T. III, No. 6, June 1960, pp. 62-65.

The general diagram of the apparatus designed for the determination of potassium vapor pressure is presented in figure 1. The potassium under study was loaded in the boiler '1', located in the muffle furnace '2', heated by carborundum heating bars '3', which assure the heating of the boiler to the necessary temperature. The boiler is made of 1X18H9T stainless steel in the form of a cylinder of 90 millimeters diameter and 15 millimeters wall thickness. The upper part of the boiler constituting a cylinder of 40 millimeters outer diameter, 10 millimeters wall thickness, and 130 millimeters length served as the potassium vapor condenser and was slightly above the furnace (ceramic) heating elements. A T-pipe is welded to the lower part of the boiler. This part of the installation operated at 150° to 200° C. A pocket for a thermocouple '7', and an extended tube '8' for the filling of the installation with metal was introduced into the boiler through the lower part of the T-shaped pipe. A pipe, which was welded at the right end of the T-pipe, connected the boiler with the pressure transducer. The remaining portions of the device are clearly shown in figure 1.

The vapor pressure of the metal was measured by a compensation-type manometer, whose sensitive part is a bellows '13' made of 1X18H9T stainless steel, composed of ten corrugations of 76 millimeters in outer diameter. The bellows displacement, produced by a difference in pressure between its inner and outer recesses was determined by a clock-type pressure indicator '12' with a 0.01-millimeter graduation. The full range of the indicator represented 10 millimeters. With an equal pressure in the two recesses of the bellows, the indicator was fixed in such a way that its mobile axis had a 5-millimeter run on each side. Such disposition was taken as initial, and the mark at which the indicator arrow pointed at that time was considered to be zero.

The observation of the bellows displacement was made through a special sight hole. In the upper part of the chamber cover was disposed a system of pipes with gates through which the outer recess of the sensitive element could be evacuated, or an excess pressure created, corresponding to that within the inner bellows. The gas pressure in the outer chamber of the bellows at zero indicator mark was equal to the pressure inside the boiler.

Prior to metal loading in the installation, a calibration of the pressure transducer was carried out. The pressure, or the discharge, created in the installation through the valve '14' was measured in millimeters of a water column by a U-shaped manometer. The calibration of the pressure transducer was made at room temperature, and at 200° C in the bellows recess. The results were as follows:

1. The zone of the pressure transducer insensitivity oscillates within the limits of 1 mm Hg.

2. The heating of the bellows recess does not influence the sensitivity of the transducer. The calculation of the sensitivity of the given manometer shows that the displacement of the bellows by one transducer indication must correspond to a pressure drop of about 0.2 mm Hg.

A special fore-vacuum pump '4' and a gas tank '5' were designed for the creation of the necessary discharge, or compensation pressure. The discharge and the pressure to 4 atmospheres were measured by the U-shaped mercury manometer '6'. Pressures above 4 atmospheres were measured by a model manometer of the 0.35 class.

The filling of the boiler by potassium from the container '11' was made by a glass capillary '10'. The inner installation recesses were depressed to 10^{-5} mm Hg. During the pumping out of the boiler, the bellows recesses and the pipe connecting them were heated to 150° C. Simultaneously with the evacuation of the inner recess of the installation, the chamber at the outer part of the bellows was evacuated. At that time the indicator showed the bellows to be in a zero position. Then, the end of the capillary '10' was broken at the bottom of the feed volume '11', and the installation was filled with potassium. Thus 200 grams of potassium were fed into the boiler, the volume of which was 400 cm^3.

In the course of the experiment the potassium was maintained in a molten state at 150° C in the bellows and in the pipe connecting it with the boiler. The warming of these parts was achieved by a nichrome heater insulated by porcelain beads. The temperature in the bellows and in the pipe was controlled by a chromel-alumel thermocouple. The temperature in the boiler was determined by the emf value of the model platinum-platinum-rhodium thermocouple of the 2nd class calibrated at the Office of Weights and Measures with the help of a П П TH-1 potentiometer. The capacity of the furnace was such that the temperature of the boiler increased at a rate of 3° C per minute. Measurements of thermocouple and of potassium vapor pressure were noted at about every 0.2 atmosphere. The first indications of the model thermocouple emf were taken at temperature increase. The furnace was switched off as the regime sought for was being reached. The temperature in the boiler increased somewhat at the expense of the furnace inertia, and then began to decrease. At temperature fall, when the indicator arrow again passed through the zero mark, a new reading was taken. The third reading was again recorded at temperature increase. The mean of the three readings of thermocouple emf for the given pressure was used, since the differences between temperature readings at any one pressure in the interval from 4 to 22 atmospheres did not surpass 2° C. The work compiles results of a series of experiments covering 203 experimental points.

Within the limits of the measurement precision, all experimental results were in agreement. The results of the measurements are presented in figure 2; the data of reference 2 are also plotted, somewhat higher on the figure. At 1,280° C, the divergence is about 20 percent.

The spectroscopic analysis has shown that impurities in the investigated potassium could not influence the results of measurements $\left(\text{Ca} - 1.1 \times 10^{-3}, \text{Fe} - 3.7 \times 10^{-3}, \text{Mg} - 8.3 \times 10^{-3}, \text{Al} - 7.0 \times 10^{-4}, \text{Na} - 0.6 \times 10^{-1} \text{ percent}\right)$. Besides, at the time of corroborating the accuracy of measurements on the very same apparatus, the potassium melting point was determined to be equal to 63°, a finding which, within the limits of measurement precision, agrees well with other data.

Hence, our experiments yielded lower values during measurement of sodium and potassium vapor pressure than did the data of reference 2. The cause of such divergences remains obscure since, for lack of sufficient description of the installation referred to in reference 2, there is no way of properly analyzing them.

The results of measurements of potassium vapor pressure with a precision to 2 percent may be approximated by the equation

$$\log P_s = -\frac{4,970}{T} - 0.5 \log T + 6.160$$

where P_s is the pressure in atmospheres, and T is the temperature in degrees Kelvin.

Translated by André L. Brichant,
Technical Information and Educational Programs,
National Aeronautics and Space Administration.

REFERENCES

1. Ditchburn, R. W., and Gilmour, J. C.: The Vapor Pressures of Monatomic Vapors. Rev. Mod. Phys., vol. 13, no. 4, Oct. 1941, pp. 310-327.

2. Makansi, M. M., Muendel, C. H., and Selke, W. A.: Vapor Pressure of Potassium. Jour. Phys. Chem., vol. 60, 1956, p. 128.*

3. Kirilov, P. L., and Grachev, N. S.: Inzhenerno-Fizicheskiy Zhurnal, T. II, No. 5, 3, 1959.

F
6
6

*NASA editor's note: This article appears as a brief communication over the names of M. M. Makansi, M. Madsen, W. A. Selke, and C. F. Bonilla; the article by Makansi, Muendel, and Selke was merely referenced in that communication.

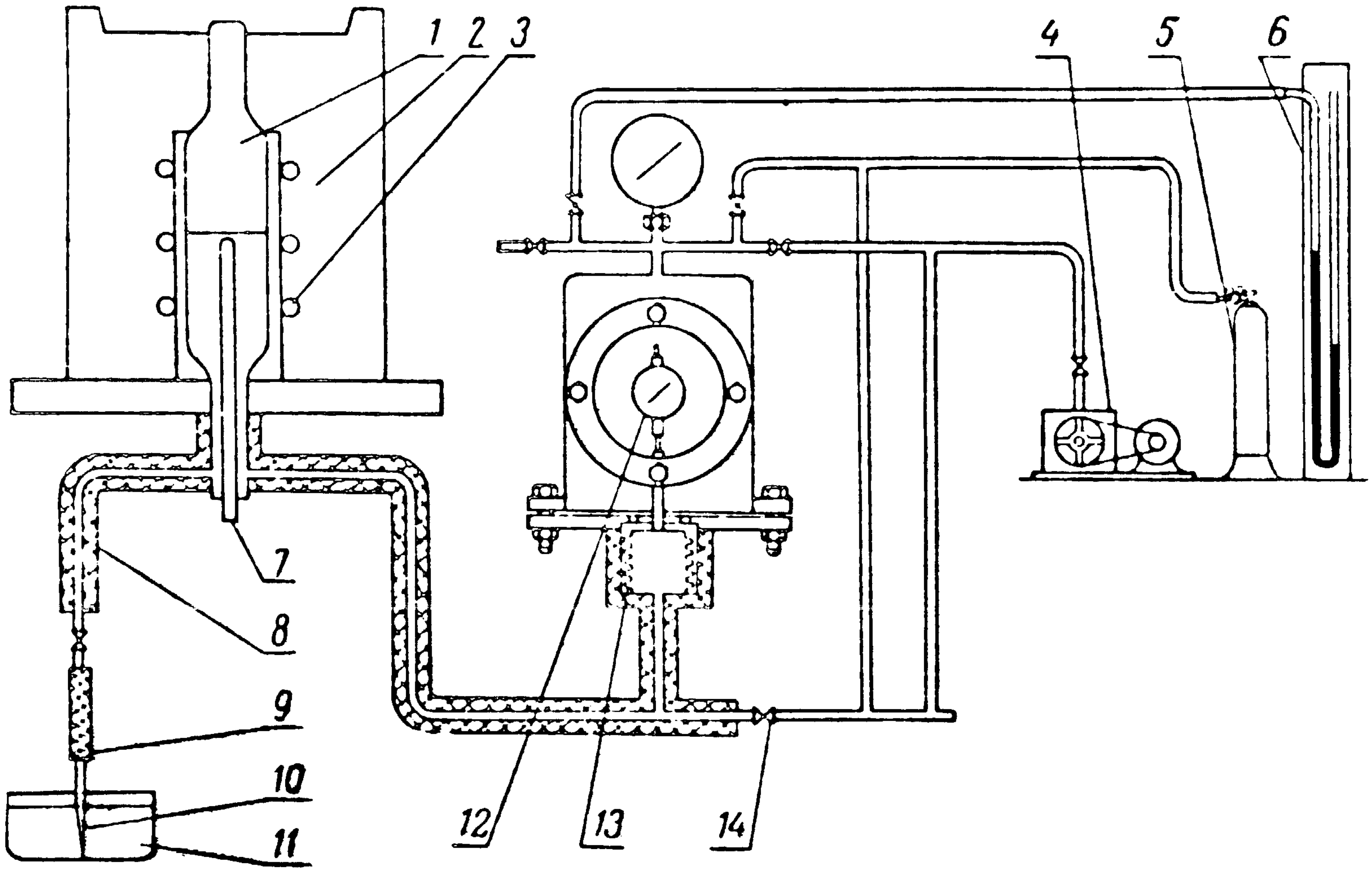

Figure 1.- Diagram of an experimental apparatus for the measurement of potassium vapor pressure (ref. numbers - in text).

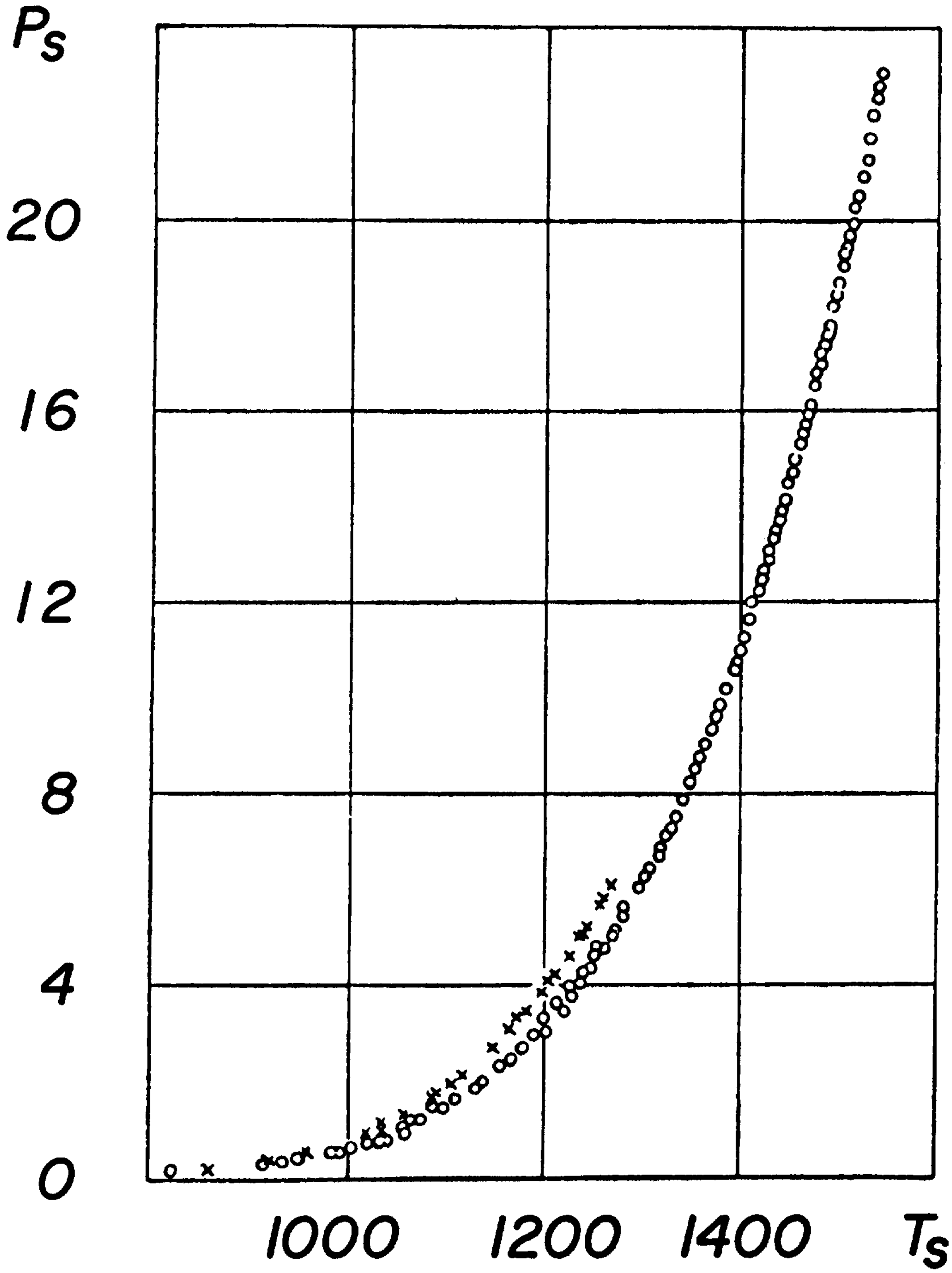

Figure 2.- Potassium vapor pressure (atm.) as a function of temperature, °K. The crosses indicate the data presented in reference 2.